Radiofrequency ablation for atrial fibrillation

P. Jaïs¹, D.C. Shah², M. Hocini¹, L. Macle¹, K.-J. Choi¹, M. Haïssaguerre¹ and J. Clémenty¹

¹Hôpital Cardiologique du Haut-Lévêque, Bordeaux-Pessac, France
²Hôpital Cantonal, University of Geneva, Switzerland

Complete cure of atrial fibrillation in highly symptomatic patients can now be achieved using a surgical or catheter based approach. Most electrophysiology laboratories working on catheter ablation for paroxysmal atrial fibrillation target pulmonary veins using a transseptal approach. The aim of the procedure is to achieve complete disconnection of the pulmonary veins, demonstrated by the disappearance or dissociation of their potentials. This is clearly facilitated by the use of a circular catheter dedicated to the mapping of the pulmonary vein ostia, which allows the identification of the connections from the atrium to the vein. Using this approach in targeting all four pulmonary veins, 70% of patients are cured without the need for antiarrhythmic drugs. However, some complications have been described, including tamponade, embolic events and pulmonary vein stenosis. The learning curve for this procedure is steep, but in experienced centres the safety profile is very acceptable.

© 2003 The European Society of Cardiology. Published by Elsevier Science Ltd. All rights reserved

KEYWORDS
Atria; Atrial fibrillation; Catheter ablation; Pulmonary veins

Introduction

Atrial fibrillation (AF) is the most common arrhythmia, with more than 1% of the general population affected.¹⁻³ This arrhythmia is responsible for significant costs and complications, but most importantly it may be very disabling in some patients.⁴⁻⁸ For such highly symptomatic patients, there are only two curative approaches: catheter ablation and surgery.⁹⁻²⁷ For patients in whom surgery is not required for other reasons, catheter ablation offers a lower morbidity and mortality, and this procedure should therefore be considered first. In contrast, a surgical approach is preferred in those patients in whom cardiac surgery is required for another reason. The present review focuses on catheter ablation for patients with AF.

Indications

Atrial fibrillation associated with another arrhythmia

In patients in whom junctional tachycardia, atrial tachycardia, or flutter is diagnosed in association with AF, the ablation should of course target the simplest arrhythmia first. This situation is frequently observed in cases of Wolff—Parkinson—White syndrome or concealed accessory pathway, but it may also be seen with atrioventricular nodal re-entry tachycardia. The patient should be considered for AF ablation if AF persists after ablation of the other arrhythmia. Indeed, most patients with both AF and flutter will continue to have AF after flutter is ablated. After ablation of
the cavotricuspid isthmus for flutter, it is probably
easier to manage patients with medical therapy
and, in particular, class IC drugs.

**Paroxysmal atrial fibrillation**

Radiofrequency ablation for AF is a relatively new
procedure. The procedure has been shortened
and simplified, and it is becoming increasingly safe
with a reasonable rate of success. However, the
present approach can probably be developed
further. The indications currently accepted will
probably be extended in the near future. We
consider for ablation those patients who have
frequent episodes of fibrillation in spite of the use
of two different antiarrhythmic drugs of class I or
III. At least one episode of AF every 10 days is
currently required, but this restriction may be
relaxed in the future. However, it will probably
never make sense to perform this kind of procedure
in patients with infrequent episodes of AF.

It is probably preferable to offer this procedure
to highly symptomatic patients. The level of
complications is likely to be the same in
symptomatic and asymptomatic patients, but to
date there has been no demonstration of a
beneficial effect of ablation on prognosis.

**Chronic atrial fibrillation**

Chronic AF is the most difficult form of arrhythmia
to ablate. Currently, there is no consensus on the
best approach for catheter ablation for patients
with chronic AF. It will probably require the
combination of long linear lesions in the left atrium
as well as the ablation of all potential foci.
Compared with the ablation of paroxysmal AF, the
procedure is much longer and the associated risks
are higher, which limits the indications. We
consider only selected patients for ablation, namely
those who are highly symptomatic and with poor
haemodynamic tolerance and/or suspicion of
tachycardiomyopathy. However, in elderly patients,
His bundle ablation and pacemaker implantation is
certainly easier and should probably be offered,
despite the minimal risk for sudden death.

**Methods**

It is preferable to refer patients with AF to an
experienced laboratory. The procedure requires
the operator to be well experienced in the
transseptal approach and catheter ablation in the
left heart, including pulmonary veins, and the
learning curve is rather steep.

It is probably safer to prepare patients with oral
anticoagulation for at least 1 month before
ablation. However, we have not demonstrated the
superiority of this in a randomized study. In
addition, transoesophageal echocardiography is
systematically performed in our department to
rule out the presence of a left atrial thrombus,
which is found in approximately 1% of referred
patients who were properly anticoagulated.

Various approaches have been described for AF
ablation. In recent years the initiation of AF has
been studied in more detail, demonstrating that
most AF episodes are triggered by a limited
number of foci located within the pulmonary veins
in 80—95% of cases. In our early experience, foci were ablated by targeting the
earliest activity in the vein during ectopy. However,
this limited lesion of the myocardial
sleeves extending into the pulmonary veins cannot
prevent firing from an adjacent site. A complete
disconnection of the vein has been shown to be
effective at circumventing this. There is no
general consensus for targeting pulmonary veins to
cure patients with paroxysmal AF, but the vast
majority of centres are doing so but with minor
variations. The most popular approach consists of
using a circular decapolar catheter to map the
ostium of the veins and to guide the ablation using
a conventional ablation catheter (Figs 1 and 2).
The major contribution of this mapping catheter is
that it allows the identification of the electrical
inputs from the atria to the veins. These areas
show the shortest atrial—pulmonary venous
potential (PVP) delay in sinus rhythm or during
coronary sinus pacing. Coronary sinus or left
appendage pacing is very useful for differentiating
between atrial and venous potentials. It also
provides a very clear end-point — all venous
potentials must disappear or be dissociated after
the ablation. With this approach the first lesion is
placed proximal to the circular catheter in front of
the bipole showing the shortest A—PVP delay. If
the circular catheter activation is unchanged, then
further lesions must be applied in the same area.
In contrast, if the activation recorded in the vein
is modified, then the bipole showing the ‘new’
shortest A—PVP delay must be targeted, and so on
until complete disconnection of the vein is
achieved, as demonstrated by disappearance or
dissociation of all distal PVPs. The most
‘electrophysiologically correct’ approach should
consist of targeting arrhythmogenic pulmonary
veins only. However, a combination of empirical
evidence and a pragmatic approach suggests that
systematic ablation of all four pulmonary veins
should reduce the number of procedures required
to achieve a complete cure. Again, this is acceptable only if the risk of pulmonary vein stenosis is very low, as in experienced centres. Using this approach, 99% of the veins are successfully disconnected. The rate of recurrence of AF remains quite high, requiring more than one procedure in 40–50% of patients. However, the success rate is reasonable. Of patients undergoing ablation, 70% are cured without any treatment with antiarrhythmic drugs. With the use of a previously ineffective class IC drug, another 15% of patients are rendered free from arrhythmia.

Fig. 1 (a) The left inferior pulmonary vein (LIPV) is mapped using a decapolar circular catheter. Recordings from lead II, the ablation electrode (Abl), the circular catheter (from 1–2 to 1–10) and the coronary sinus (CS) are shown. Panel 1: During CS pacing, the LIPV is activated the earliest from its inferior part (6–7) with a minimum delay from the pacing artifact to pulmonary venous potential (PVP) of 180 ms and 220 ms at the top (1–2, 1–10). The ablation therefore targets the inferior segment of the ostium. As a consequence, in panel 2, activation is delayed in 6–7 to 200 ms but has not changed in 1–2 (220 ms), suggesting another input in the superior part of the vein. Fractionated potentials are recorded with the ablation catheter in the superior part of the vein, as shown in panel 3. This potential bridges the A–PVP interval, suggesting that this is one site of conduction into the vein. As shown in panel 4, ablation at this site results in a significant delay in 1–2 but not in 6–7, demonstrating that the inferior input has not been completely ablated. In panel 5, radiofrequency energy is again delivered at 6–7 and results in delayed activation of PVP in both bipoles 6–7 as well as 1–2 (+50 ms), suggesting that the inferior input is now the only remaining connection to the distal PV because the superior input has been completely ablated. One more application of radiofrequency proximal to 6–7 produces a complete electrical disconnection of the LIPV (b). Note that there is transient recovery of conduction for 3 beats after the initial achievement of block (first arrow).
Another approach consists of long linear lesions encircling the pulmonary vein ostia, four-by-four or two-by-two, as developed by Melo et al.\textsuperscript{17} and Sueda et al.\textsuperscript{18} This approach has been translated to catheter ablation by Kuck and coworkers\textsuperscript{19} and by Pappone et al.,\textsuperscript{20} with differences in effectiveness and complication rates. However, the most recent results reported by Pappone et al.\textsuperscript{21} are encouraging, with similar success rates both for patients with paroxysmal AF and for those with chronic AF.

What are the risks and how can they be reduced?

In addition to the risks inherent to any cardiac catheterization, there are more specific risks associated with AF ablation.

Transseptal puncture and use of long sheaths in the left atrium

The transseptal puncture is performed using dedicated transseptal sheaths. Once the puncture is made with the Brockenbrough needle, the dilator and sheaths are only pushed over the needle if there is 100% confidence that the tip of the needle is in the left atrium. In our experience, the analysis of the pressure recorded by the needle is not sufficient proof of this, and injection of contrast through the needle may increase safety by showing whether the tip of the needle is in the left atrium.

Once the long sheath is introduced into the heart, it is perfused under pressure to deliver a flow of approximately 2–4 ml/min.

**Thromboembolic complications**

In our series of patients, the risk for thromboembolic complications was lower than 0.5%. To reduce the risk as much as possible, the following measures are used.

Oral anticoagulation is interrupted 2 or 3 days before the ablation, which is performed in our laboratory when the INR is below 1.7. After this, a bolus of heparin 50 U/kg body weight is infused and repeated only if the procedure lasts longer than 3–4 h. After ablation, subcutaneous heparin is administered with a target of two or three times the control value for the partial prothromboplastin time.

During the procedure, radiofrequency energy is delivered using the temperature controlled mode with a target temperature of 50°C. With such a low temperature of the ablation electrode, charring or clot formation is uncommon and this probably, in part, explains the safety profile of the procedure.

**Vein stenosis**

In our initial experience, the use of powers ranging from 40 to 50 W was associated with pulmonary vein stenosis in 5% of cases. By decreasing the power limit to 20–30 W, the incidence of this complication has been reduced to about 1%.
Mechanical complications

Perforation may be observed during manipulation of the ablation catheter in the left atrium, particularly in the left appendage, where very thin tissue is encountered between pectinate muscle and in the roof of the left atrium where the ablation catheter is pushed after crossing the septum. The optimal use of a circular catheter also involves a learning curve. Because of the circular orientation with the proximal poles attached to the shaft of the catheter, it is safer to turn the shaft clockwise. A counter-clockwise rotation will uncoil the circular catheter, which may be unsafe. Moreover, the circular catheter should not be uncoiled in the left ventricle because it may become entrapped in the chordae of the mitral valve.

Conclusion

More than 70% of patients with paroxysmal AF may now be completely cured with transseptal catheter ablation of pulmonary veins. Despite some variation, the present approach used in most electrophysiology laboratories aims to disconnect pulmonary veins from the left atrium. At the present time, it makes sense to offer this treatment to highly symptomatic patients in whom antiarrhythmic treatment has failed. Presently, it makes sense to offer this treatment to highly symptomatic patients in whom most antiarrhythmic treatment secondary to an atrial focus. J Am Coll Cardiol 1999;33:1217–26.

References
